Feb. 4, 1936. J. S. PARKINSON 2,029,441

ACOUSTICAL STRUCTURE

Filed Dec. 12, 1933

Fig. 1.

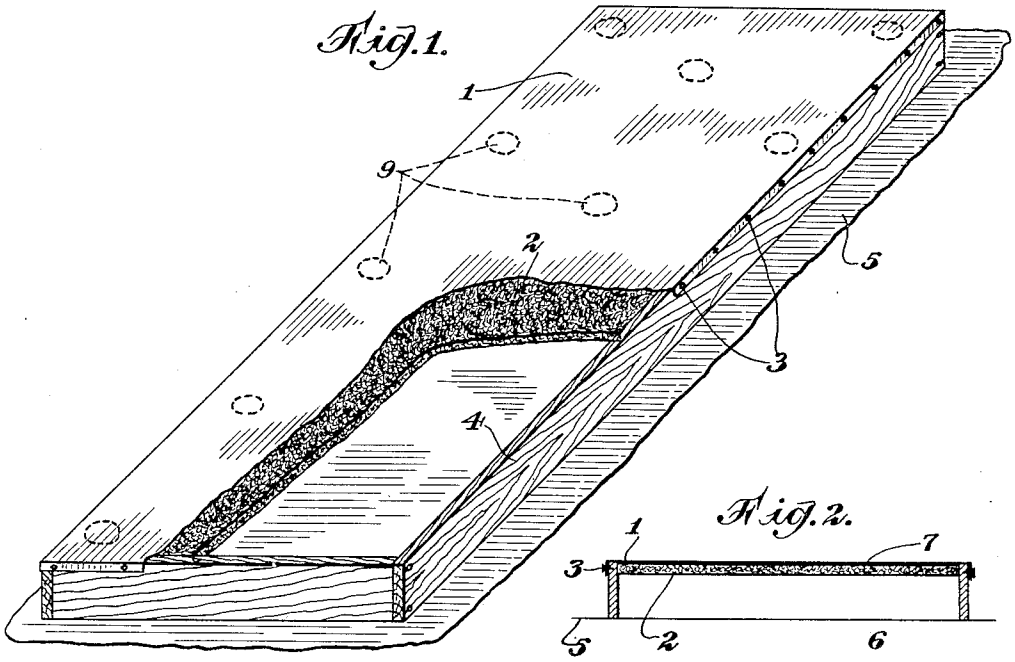


Fig. 2.

Fig. 3.

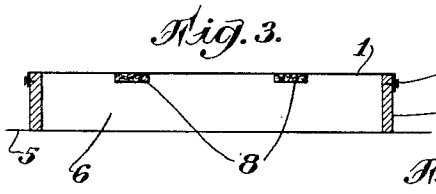


Fig. 4.

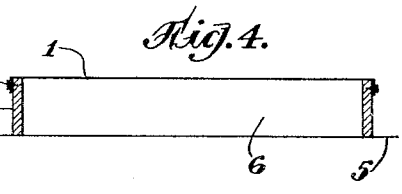
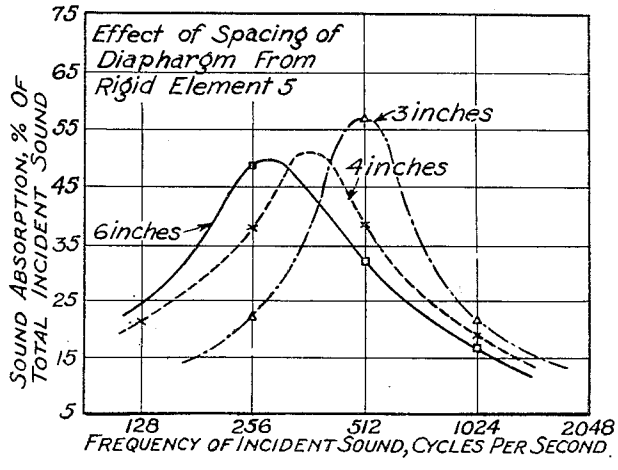


Fig. 5.



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ACOUSTICAL STRUCTURE

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Application December 12, 1933, Serial No. 701,962

14 Claims. (Cl. 181—30)

This invention relates to an acoustical structure and particularly to one that is adapted for use in the absorption of sound of low frequency, such, for example as that emitted by an airplane motor.

Airplane motors give a very large amount of sound of a frequency of about 250 to 400 cycles per second. The commonly used acoustical materials, on the other hand, show a maximum absorption efficiency for sounds of frequency considerably above this range. To absorb a satisfactory proportion of sound of the frequency given by the motors would require such a thickness of material or type of construction, with certain conventional sound absorbents, as to increase undesirably the weight of the installation.

It is an object of the present invention to provide a lightweight acoustical structure that shows a peak or an optimum absorption in the range of about 250 to 400 cycles. A further object is to provide such a structure having a face that is non-porous, not susceptible to penetration by dirt or dust, and that may be decorated or washed without appreciable injury. Another object is to provide a non-fragile acoustical structure that is resistant to permanent deformation. Other objects and advantages will appear from the following description and the appended claims.

While the invention may be embodied in various forms, an embodiment that is preferred at this time is illustrated in the drawing and is described in connection therewith.

Fig. 1 shows a perspective view, in part broken away for clearness of illustration, of a structure made in accordance with the present invention;

Fig. 2 shows a cross sectional view of a structure similar to that of Fig. 1 in which a felt backing is continuously adhered to the non-porous facing member or diaphragm;

Fig. 3 shows a cross sectional view of a similar structure in which the continuous backing member is replaced by several small units of such material adhered to the diaphragm in selected localized areas;

Fig. 4 shows a structure adaptable for certain purposes in which the backing material is eliminated, the structure being otherwise similar to that shown in Fig. 1; and

Fig. 5 shows graphically the results obtained in absorbing sound of several frequencies for various spacings of the diaphragm from the rigid base member or wall.

There is shown a facing member 1, a backing material 2, a supporting frame 4, and a base material in the form of the sheet 5. The facing member is in contact with the backing material and is secured, as by the tacks 3, to the frame and supported thereby in spaced relationship to the base material.

The sheet 5 is illustrative of a structural material, as, for example, the air-impermeable metal sheet of an airplane cabin.

The frame 4 may be of wood or other rigid material. The various elements of the frame may consist of struts, bracings, or other reenforcing or supporting elements in an airplane or the like. Thus, the supporting framework may serve solely the purpose of holding the facing element and the material adhered thereto, or it may serve also to reenforce the member 5 and enclose the air space 6.

The facing member 1 should be non-permeable and readily vibratile under the influence of incident sound, that is, in the absence of the material 2, and is suitably a woven textile fabric coated with an impermeable film that is vibratile in the finished member. Thus, there may be used a strong silk fabric or, preferably, airplane linen. The fabric is moderately stretched and secured to rigid supports, such as the sides of the frame 4, and then is provided with a coating of the type obtained by doping and allowing the volatile solvents therein to evaporate. The fabric is thus made taut. The tension thereon is maintained by the frame support 4.

When tapped with the finger, for example, the member emits a noise that is more or less drum-like. Also, the doped facing member is adapted to vibrate or to resonate under the influence of incident sound. For the purpose of the present invention, the resonance frequency of the member in the structure should be in the range of frequency of the sound that is to be absorbed. It will be understood that the resonance frequency of a vibratile membrane of this type depends largely upon its mass and tautness, and that one skilled in the art may produce membranes adapted to resonate at the frequency desired, within the considerable range that is allowable. Airplane linen, stretched and doped in accordance with the practice prevailing in covering the wing of a cloth-winged airplane, has been used with satisfaction. The lightness of such membranes adapts them to vibrate readily.

The material 2 disposed behind the facing member should be lightweight, yet not so light as to absorb no appreciable energy in being moved, yieldable, non-vibratile, and adapted to damp vibration of the facing member. Such a material is a fibrous felt of hair, wool, or the like. The

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thickness of layer of the material 2 may vary over a substantial range, one-fourth inch being a satisfactory thickness.

The damping member is said to be non-vibratile in the sense that the member alone is not susceptible to vibration, although it may move, in certain parts at least, in periodic manner under the influence of an adhered vibrating element.

In general, the vibration-damping material is adhered to the vibratile facing member at an internodal position thereon, that is, at a position substantially removed from the places of support of the said member upon a frame. These positions of support, as illustrated in Figs. 1, 2, and 3, are necessarily nodal positions.

It is convenient, in obtaining adequate, permanent contact with the member 1, to adhere the material 2 over its contacting surface, either substantially continuously as illustrated at 7, which indicates adhesive, or in localized areas 9, to the back of the facing member. Particularly good results with economy of material have been obtained when the backing material in the form of discontinuous patches is adhered in localized areas 8 that may be each of small area and spaced variously, as, for example, approximately five of such areas to the square foot of membrane. The said localized areas are internodal and may approximate the antinodal points on the diaphragm when vibrated before the application of the backing thereto. Also, other means for holding the felt in contact with the vibratile member may be used, as, for example, independent, yieldable holding elements. As these elements may be conventional, they are not illustrated.

The adhesive 7 that may be used to adhere the material 2 to the facing member 1 may consist of any suitable composition. While sodium silicate may be used, the adhesive is preferably one that, in the form of the final film, is durable and firmly adherent to both the felt and the fabric 1. The adhesive film may consist largely of a resin, such as pontianak, or other material that is compatible with and adherent to the dope or coating on the facing member as well as to the felt.

In the modification of the invention illustrated in Fig. 4, the backing material is omitted. In this modification the deadening of incident sound is dependent entirely upon coaction between the facing member or vibratile diaphragm and the other elements of the structure. Best results are obtained when the supporting framework, rigid backing member, and diaphragm confine air in the space 6, so that the diaphragm, in vibrating, must alternately compress and rarefy the confined air.

Various spacings of the assembly of the backing material 2 and the facing member 1 from the base member 5 may be used. Particularly good results have been obtained when the distance between members 1 and 5 equals approximately one-eighth of the predominant or average wave length of the sound to be absorbed, say, 2 to 6 inches, considerable variation being allowable and the exact spacing selected in a commercial installation depending, in part, upon the space available.

The results which are shown in graphic form in Fig. 5 illustrate the remarkable effects obtained from proper choice of spacing of the diaphragm 1 from the base member 5. These results were obtained with the modification of the invention illustrated in Fig. 4, in which no vibration-damping material is adhered to the back of the facing member 1 and the air space between the member 1 and 5 is enclosed by the framework 4, in such manner as to minimize the circulation of air between the inside of the structure and the outside. From the known velocity of sound and from the data plotted in Fig. 5, it may be calculated that for the incident sound of a given frequency the maximum sound absorption, as indicated by the peak in the appropriate graph, occurs when the spacing of the diaphragm from the base member 5 is approximately one-eighth of the wave length of the sound. Thus, the sound of 256 cycles frequency has a complete wave length slightly greater than 4 feet and the maximum absorption of sound of that frequency is obtained when the diaphragm is spaced slightly more than 6 inches from the base 5, 6 inches being one-eighth of 4 feet. Likewise, the optimum results with sound of 512 cycles is obtained when the spacing is approximately 3 inches. For most sounds, a spacing of the diaphragm 1 approximately 2 to 6 inches from the base 5 is desirable.

It will be understood that the term sound absorption as here used includes sound deadening. That is, any sound absorption in the usual sense may be supplemented by the deadening of sound by work done upon the sound-impermeable diaphragm 1 or upon the air confined therebehind. So far as the applicant is aware, he is the first to observe the importance of the critical spacing of the diaphragm from the base member of the type illustrated at 5, the deadening of sound by means of a sound-impermeable, readily vibratile diaphragm, or the result obtained by associating the said diaphragm with a vibration-damping material.

With a construction of the type illustrated in Fig. 1 in which the facing member consisted of doped airplane linen and was spaced at a distance of three inches from the member 5, in this instance a section of a concrete floor, there has been obtained an absorption of 55% of incident sound of a frequency of 256 cycles and 82% of incident sound of a frequency of 512 cycles.

The nature of the results will be more surprising when it is recognized that heretofore high efficiencies in sound-absorption have been obtained when the incident sound had access to a porous sound-absorbing structure, either directly or through a sound-permeable facing member, such as cloth having open meshes therein or a closely perforated metal sheet.

The explanation of the surprising results now obtained, when the facing member is not permeable to sound, is not necessary to the invention or to the present description thereof. However, the following theories are suggested. Sound striking the facing member 1, of the type described, tends to set the facing member in sympathetic vibration, the energy of the incident sound being converted to a large degree into the energy of the vibration. But as the member 1 vibrates, it must alternately compress and expand the non-vibratile material 2 in contact with the member 1. As a result, the energy of vibration is largely consumed in work done upon the member 1 and the material 2, and the member does not vibrate sufficiently to regenerate a large proportion of the sound originally incident thereupon. When the material 2 is also sound-absorbing, as well as vibration-damping, as is true of the fibrous felts suggested, any small amount of sound generated by the vibrating member 1 is

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absorbed, in part, by the member 2. Also, the air between the facing member and the air-impermeable base 5 may contribute to the damping effect, by the small amount of work done upon the air by alternate slight compression and rarefaction.

Permeability, as referred to herein, unless otherwise specified, refers to permeability to airborne sound waves.

It will be understood that the resonance frequency of the facing member in the structure is affected by factors other than the properties of the facing member itself and that the term "resonance frequency", as applied to the facing member, refers to the resonance frequency of the member in the finished, complete structure.

The details that have been given are for the purpose of illustration, not restriction, and variations within the scope of the appended claims may be made without departing from the spirit of the invention.

What I claim is:

1. A sound-absorbing structure comprising a facing member maintained under tension and adapted to be set in vibration by incident sound and lightweight, yieldable, non-vibratile, vibration-damping material disposed behind and in contact with the said facing member at an internodal position thereon.

2. A sound-absorbing structure comprising an impermeable member adapted to be set in vibration by incident sound and lightweight, yieldable, non-vibratile, vibration-damping material disposed in contact with the said member at an internodal position thereon.

3. A sound-absorbing structure comprising an impermeable facing member adapted to be set in vibration by incident sound, and lightweight, non-vibratile, yieldable, sound-absorbing material secured to the back of the facing member at an internodal position thereon.

4. A structure, adapted to absorb incident sound, comprising a readily vibratile facing member of resonance frequency in the range of the frequency of the incident sound and lightweight, yieldable, non-vibratile, vibration-damping material disposed in contact with the facing member at an internodal position thereon.

5. A structure, adapted to absorb incident sound, comprising a readily vibratile facing member including a taut, coated, impermeable fabric of resonance frequency in the range of the frequency of the incident sound and lightweight, yieldable, non-vibratile, vibration-damping material disposed in contact with the facing member.

6. A sound-absorbing structure comprising a readily vibratile facing member including a taut, impermeable, coated fabric adapted to be set in vibration by incident sound and lightweight, yieldable, non-vibratile, felted fibrous material disposed in contact with the facing member.

7. A sound-absorbing structure comprising an air-impermeable support, a lightweight, yieldable, vibration-damping material disposed in spaced relationship to the support, and an impermeable facing element, adapted to be set in vibration by incident sound, adhered at an internodal position to the side of the vibration-damping material remote from the said support.

8. A sound-absorbing structure comprising an air-impermeable support, a lightweight, yieldable, vibration-damping material disposed in spaced relationship to the support, at a distance of the order of two to six inches, and an impermeable facing member, adapted to be set in vibration by incident sound, adhered at an internodal position to the side of the vibration-damping material remote from the said support.

9. A sound-absorbing structure comprising an air-impermeable support, a lightweight, yieldable, vibration-damping material disposed in spaced relationship to the support, and an impermeable facing member, adapted to be set in vibration by incident sound, adhered at an internodal position to the vibration-damping material.

10. A structure adapted to absorb incident sound and comprising an air-impermeable, rigid support, a taut readily vibratile facing member maintained in spaced relationship to the support, and means enclosing the space between the said member and support, whereby circulation of air between the space and the outside is restricted.

11. A structure adapted to absorb incident sound and comprising an air-impermeable, rigid support and a facing member maintained in spaced relationship to the support, at a distance therefrom approximately equal to one-eighth of the predominant or average wave length of the incident sound.

12. A structure adapted to absorb incident sound and comprising a readily vibratile facing member and discontinuous patches of vibration-damping material adhered in localized areas to the back of the facing member.

13. A structure adapted to absorb incident sound and comprising an air-impermeable, rigid support and a facing member maintained in spaced relationship to the support, at a distance therefrom approximately equal to one-eighth of the predominant or average wave length of the incident sound, the facing member in the structure having a resonance frequency in the range of the frequency of the incident sound.

14. A structure adapted to absorb incident sound and comprising an air-impermeable, rigid support and an impermeable facing member maintained in spaced relationship to the support, at a distance therefrom of approximately 2 to 6 inches.

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